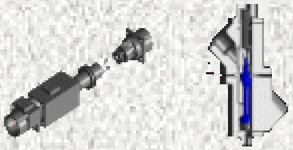
# VALVE DEVELOPMENT

# Valve Development/TD62





## Agenda

- Review of the Valve Development Task Objectives and Goals
- Light Weight Low Cost Valve Program
- Valve Development and Testing Update
- Component Development Area Plans

## MSFC’s Valve Development Objectives

- MSFC’s in-house valve design and development work makes us smarter customers.
  - Lessons learned in development of our valves helps MSFC write better specifications and verification plans for vendor valves.
  - The experience, gained through in-house design and testing, results in a better components whether designed in-house or by our vendors.
  - Simpler designs evolve from better understanding of valve manufacturing and through performing tests.
- Develop new high risk technologies.
- Next generation launch vehicles will require valves that are lighter, cheaper (to maintain and operate), and offer greater reliability (safety). A better understanding of valve component failure modes is required to achieve this objective.
- Conceptual valves (such as the “Slide” and “Able” valves) will be developed, built, and tested at MSFC in support of these objectives.

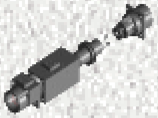
# Valve Development/TD62



## Design Goals

- Create in-house valve design capability.
- Utilize advanced technology design tool.
- To be used as a test-bed for advanced technologies in instrumentation and control, materials finishes, and manufacturing.
- The Slide valve was designed to early RBCC requirements.
  - 1500 psig; H2O2 / RP-1 applications.
  - Increased service life, safety, and reduced weight.
  - On/Off applications.

# Valve Development/TD62





## Road Map To Advanced Valve Technology Development

Task 1: Using current processes and manufacturing technologies, design and develop a propellant system control valve that will reduce the complexity, increase the reliability and is easier to assemble, install and test when integrated onto the engine.

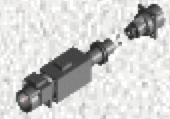
Task 2: Using the simplified valve design developed above, apply existing advanced technologies to further reduce weight, increase reliability/safety, and improve the state of the art in valve manufacturing/materials.

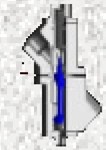
Task 3 Incorporate a valve health monitoring capability into the simplified valve design.

Task 4 Evaluate the application of newly-developed/emerging technologies for valve designs.

Task 5 Provide a valve that incorporates the most promising technologies developed and evaluated from the above tasks into a valve that provides an increase in reliability and safety while reducing the costs and operational turn-around time.

Task 6 Continue to evaluate new technologies and vendor valves for application into space flight propellant systems.





# Road Map – Task 1 – Simpler Valve Development

Task 1: Using current processes and manufacturing technologies, design and develop a propellant system control valve that will reduce the complexity, increase the reliability and is easier to assemble, install and test when integrated onto the engine.

This Includes:

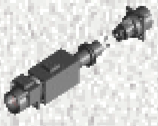
- Elimination of separate actuating systems;
- Reduction of valve piece parts;Increase cycle life through the use of better bearings and fewer seals;
- Higher safety margins;Greater reliability with less sensitivity to system contamination, and better on-board testing capabilities;
- Provide a Component Development Area within an existing facility, outfitted to support breadboard testing of this and other valve technologies.

# Road Map – Task 2 – Advanced Technology Application

Task 2: Using the simplified valve design developed in Task 1, apply existing advanced technologies to further reduce weight, increase reliability/safety, and improve the state of the art in valve manufacturing/materials.

This Includes:

- Improved materials such as metal matrix composites and Teflon impregnated electro-less nickel plating;
- Advanced manufacturing processes such as advanced casting and rapid prototyping/manufacturing technologies;
- Improve component designs such as better bearings and seals through the use of dry film lubrication, flame hardening of surfaces, and microplasmic surface finishes.





# Road Map – Task 3 – Application of Health Monitoring

Task 3: Incorporate a valve health monitoring capability into the Task 1 simplified valve design.

This Includes:

- On-board data storage for down-load after flight to assess valve suitability for re-flight;
- Flow vs. position though the use of pressure , position and stored data computations;
- Seat leakage through the use of ultrasonic transducers or other  methods;
- Actuator and bearing health through the use of position vs. actuator pressure;
- Cycle life monitoring;
- In-flight data acquisition and communication.

# Road Map – Task 4 – Application of Newly Developed Technologies

Task 4: Evaluate the application of newly developed technologies for valve designs.

This Includes:

- Shaped memory metal actuators;
- Magnetic fluid actuation;
- Nanotechnology;
- Other Advanced Concepts.

# Valve Development/TD62



## Road Map – Task 5 – Advanced Technology Valve

Task 5: Provide a valve that incorporates the most promising technologies developed and evaluated from the above tasks into a valve that provides an increase in reliability and safety while reducing the costs and operational turn-around time.

This Includes:

- Design, fabrication and breadboard testing of a candidate design;
- Integration into a IPD engine and testing;
- System testing on a flight demonstration platform (i.e. $2^{nd}$ or $3^{rd}$ Gen).

# Road Map – Task 6 – Evaluate New Vendor Valve Designs

Task 6: Continue to evaluate new technologies and vendor valves for application into space flight propellant systems.

This Includes:

- Attend conferences and seminars where new valve technologies are presented;
- Review valve manufacturers web sites, catalogs, and other published material for new valve technologies;
- Review vendor and NASA lesson learned databases for valve problems and possible solutions;
- Provide some funding to valve vendors to develop new valve technologies.

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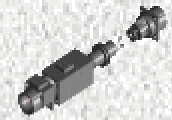
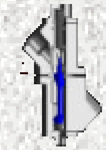




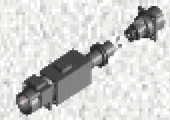
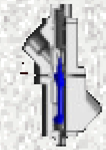


## Program Objectives

The Advanced Valve Technology task has been funded as part of the Third Generation Reusable Launch Vehicle program. This task included:

- Development of a simpler more robust valve design (see Task 1 as defined in the Road Map above),
- Establishment of a CDA to evaluate designs,
- Study the application of new technologies (see Task 2),
- Begin requirements definition, conceptual definitions and evaluations of valve health monitoring system (see Task 3),
- Review of vendor data (see Task 6).

# Valve Development/TD62



## Program Status

Three valves types are being developed.

- The “Slide” valve was developed to meet early RBCC system requirements.
  - Completed internal TD62 design review,
  - Performed flow tests on SLA model,
  - Completed fabrication,
  - Began seal testing,
  - Redesigned to resolve body burst test failure,
  - Modified bodies out for fabrication.
- The “Able” valve was developed to meet later requirements.
  - Completed conceptual studies,
  - Produced SLA model,
  - Drawings completed,
  - Parts being fabricated.
- The “Baker” valve is a pilot valve that will be used to self actuate these valves.

# Valve Development/TD62



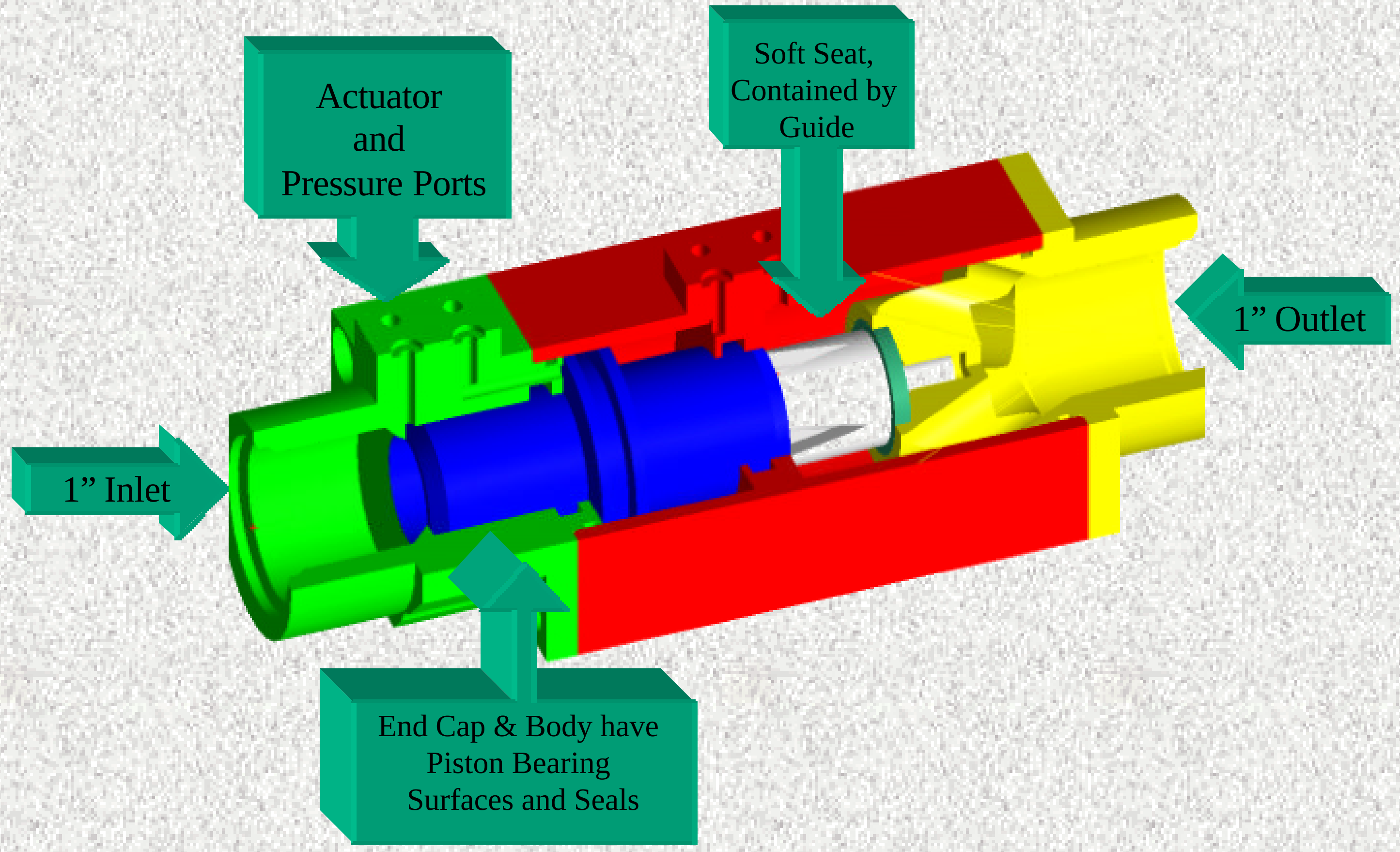
## Program Status (Cont’d)

- The Component Development Area (CDA) is established.
  - Basic equipment to begin testing ready:
    - Environmental chamber and necessary support equipment,
    - Pressure and leak testing hardware,
    - and Data acquisition and control hardware.
  - Technicians training and certification is complete.
  - Operating procedures in place.
- Have preformed limited testing for Slide valve, MC-1 (Fastrac) valves and X38 thrusters.
- Gen. 3 funding for continued valve development through FY01 and proposals for continued support for FY02 to be submitted later next month.

# Valve Development/TD62



## 1” Slide Valve - Assembly



# Valve Development/TD62



## Slide Valve Design Specifications

- 1500 psig Operation.
- Sizes, Cv, Weight, CV/#.

| | | | |
|---|---|---|---|
| – 1/2” | - Cv = Approx. 1.2 | - Approx 1.5 Lb | - Cv/# = 0.8. |
| – 3/4” | - Cv = Approx. 4 | - Approx 2.5 Lb | - Cv/# = 1.6. |
| – 1” | - Cv = Approx. 8 | - Approx 3 Lb | - Cv/# = 2.7. |
| – 1-1/2” | - Cv = Approx. 20 | - Approx 4 Lb | - Cv/# = 5.0. |
| – 2” | - Cv = Approx. 30 | - Approx 5 Lb | - Cv/# = 6.0. |

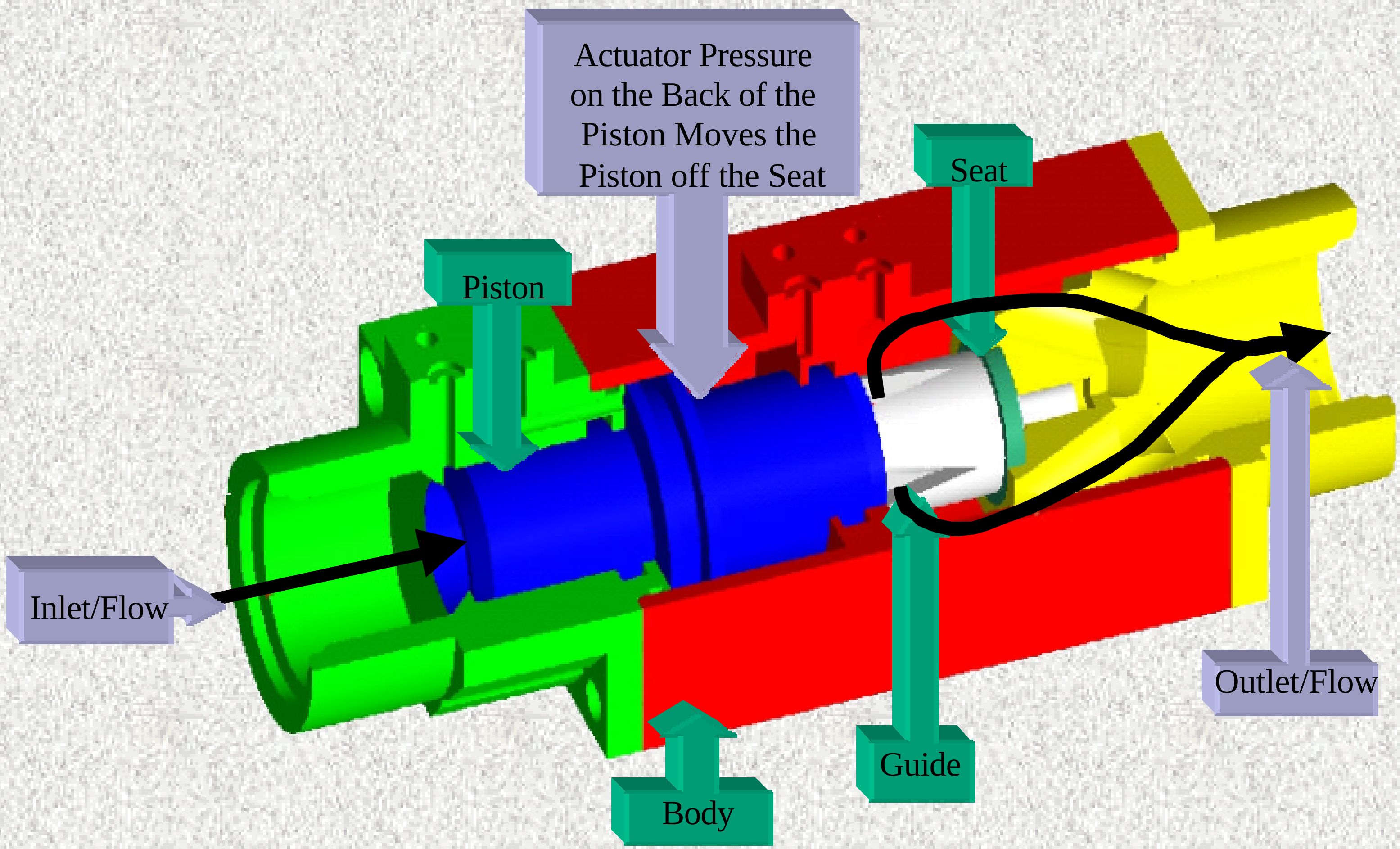
- Media:
  - Gases including GN2, GHe & Air - using internal gas to drive actuator.
  - Liquids including RP-1, H2O2, LOX*, LN2*, LH2*.

    * using external gas to drive actuator.
  - Can use actuator pressures as low as 750 psig, up to full line pressure.
- Materials: Body and Internal parts:Anodized and Teflon Coated 6061-T6 Aluminum; Seals: Teflon, or others as needed.

# Valve Development/TD62



## 1” Slide Valve - Internal View - Open



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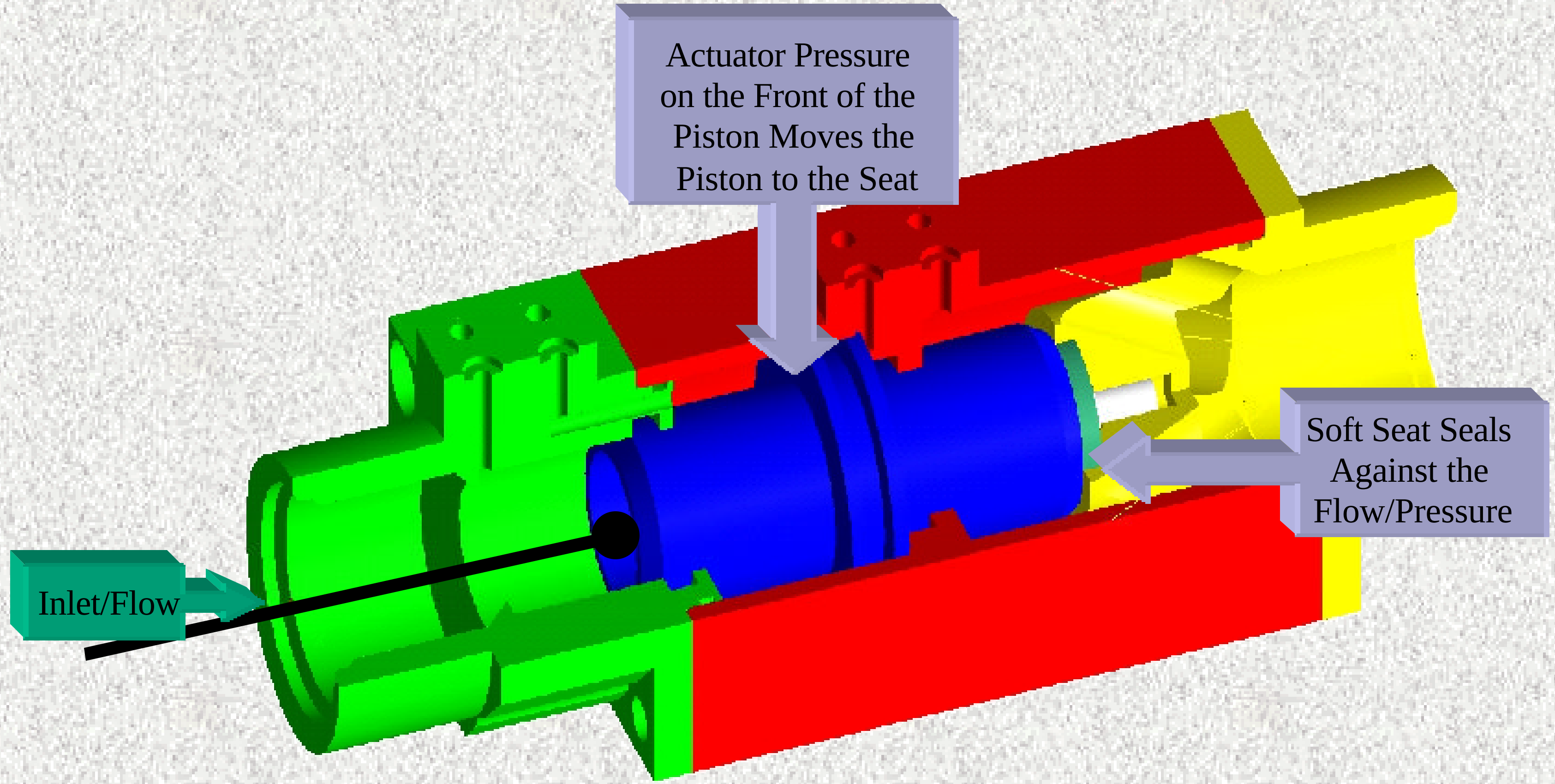
## 1” Slide Valve - Internal View - Closed



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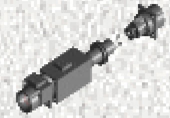
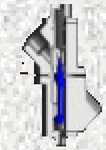
# Valve Development/TD62





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## Comparison To Other Typical Valves

| PARAMETER | SLIDE VALVE | BALL VALVE | POPPET VALVE |
|---|---|---|---|
| Flow (Typical) | 4 Cv/Lb | 14 Cv/Lb w/o Actuator | 1.5 Cv/Lb |
| Control | Good | Poor | Best |
| Service Life Factors | Few Moving Parts, Large Bearing Surfaces | Shear Across Seals, Rotary Seals | High Bearing Loads |
| Moving Parts | 1 | 5 | 5 |
| Pressure Balanced | Yes | No | Maybe |
| Sizes Where Propertied are Similar | ½ to 4” | ½” to 18” | ½” to 4” |
| Dynamic Seals | Internal, Linear | External, Rotary | External, Linear |
| Seal Friction | Minimum Seal Loads | Higher Seal Loads | Lowest Seal Loads |
| Actuator Type | Internal Piston | External Rotary | External Piston |
| Response Time | Less than 100 msec | Typically > 250 msec | Approx 150 msec |
| Position Sensors | On-Off | Variable/On-Off | Variable/On-Off |

# Valve Development/TD62



## Slide Valve Heritage

### Assured Automations VA Series Valve:

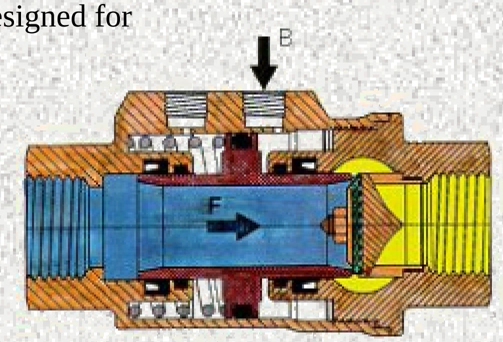
**COMPACT:** The VA Series combines a pneumatic actuator and valve into one body, eliminating packing glands, actuators and mounting kits.

**SAFE:** There are no exposed moving parts, eliminating pinch points and increasing operator safety.

**COMPETITIVE:** Since the actuator is part of the valve, costs are greatly reduced when compared to standard actuated valves.

**EXTENDED LIFE CYCLE:** Operating life has been tested to well over 1,000,000 cycles, the balanced design reduces friction and wear. The stroke is linear and parallel to the flow reducing the force to close or open the valve dramatically.

**FLOW CHARACTERISTICS:** The internal waterway design was designed for optimum flow characteristics.



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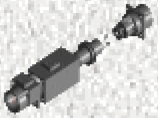





## Moving Target

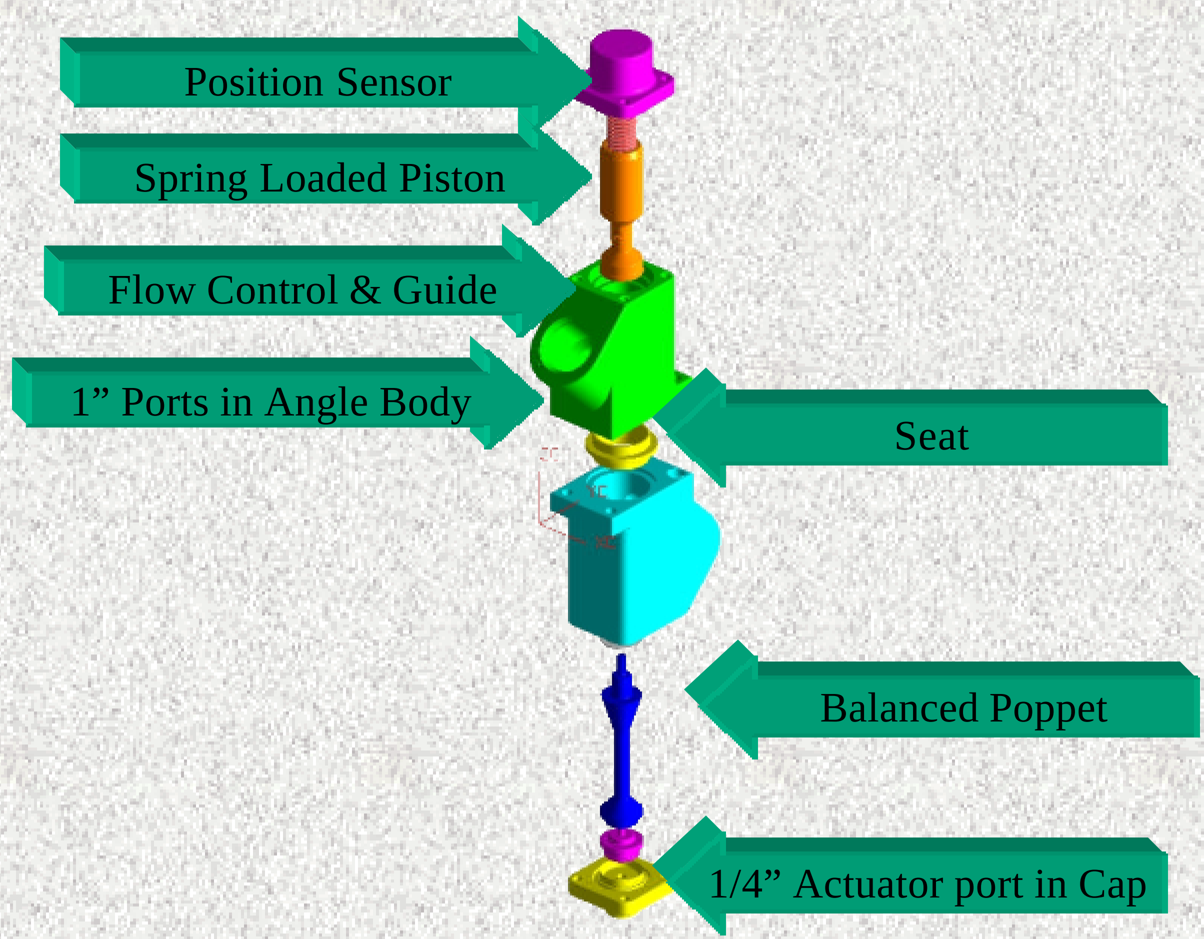
- Changes in RBCC Valve Objectives lead to modification of slide valve concept, resulting in the Able valve concept.
- RBCC Design Objectives Changed to:

| Parameter | 1" Valve | 1/4" Valve |
|---|---|---|
| **Pressure** | 3000 psig | 2000 psig |
| **Temperature** | 150 to -320 Deg F | 150 to -320 Deg F |
| **Flowrate** | 37 lbs/sec | 0.5 lbs/sec |
| **Pressure Drop** | <100 psig | <200 psig |
| **Response Time** | <0.5 sec | <0.15 sec |
| **Leakage** | 100 SCIM | 100 SCIM |
| **Life Cycles- Wet** | 1000 | 1000 |
| **Life Cycles- Dry** | 5000 | 5000 |
| **Weight (Max)** | 5.0 lb | 2.0 lb |
| **Ramp Rate** | 200 %/sec | 667%/sec |
| **Shelf Life** | 5 yr | 5 yr |
| **Position Indication** | Continuous | Continuous |
| **Position Accuracy** | "+/- 1.0 % | "+/- 0.1 % |

# Valve Development/TD62



## 1” Able Valve - Exploded View



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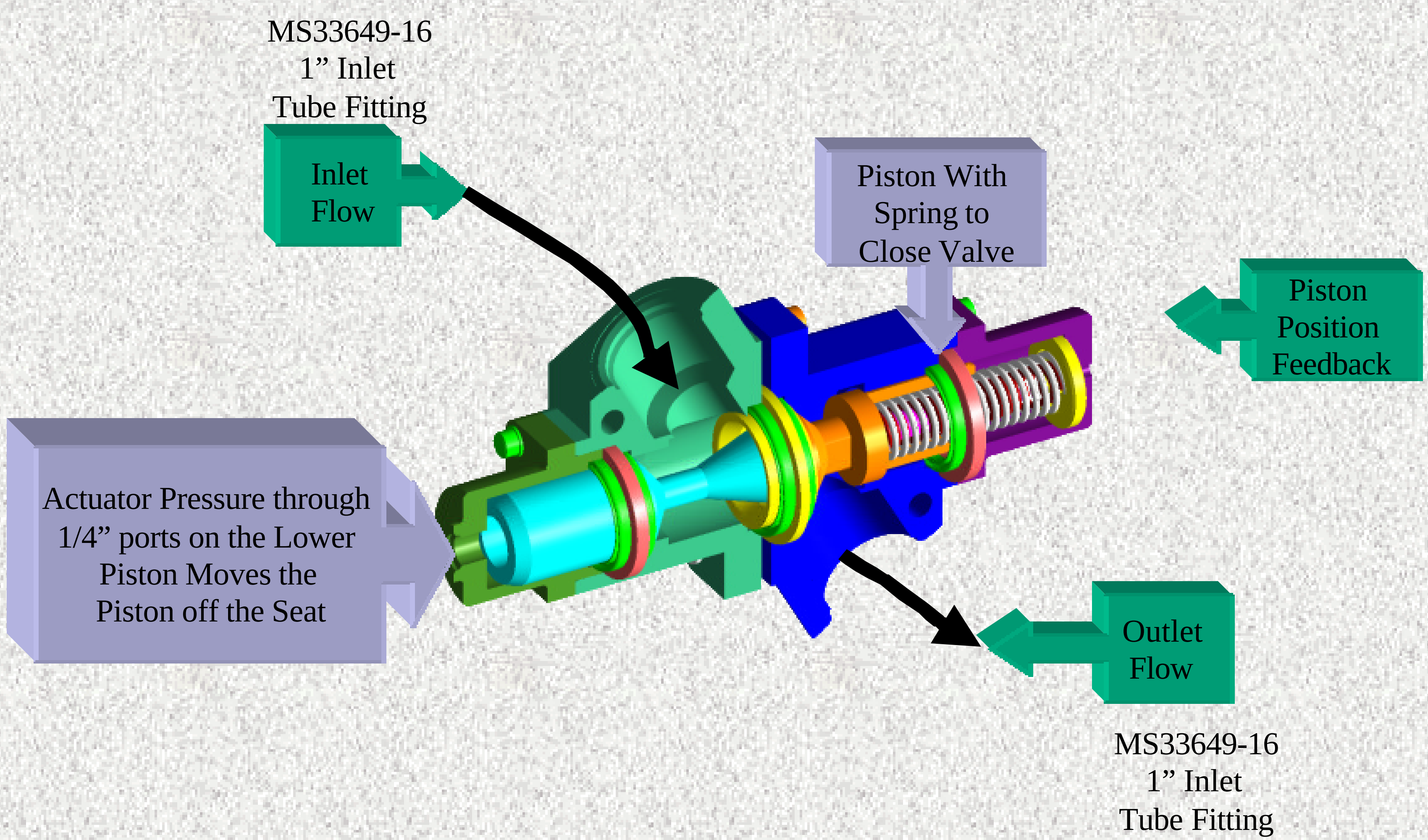
## 1” Able Valve - Internal View



# Valve Development/TD62



## Component Development Area


Component testing to verify requirements are met.

# Valve Development/TD62



## "If You Build It They Will Come!"

- MSFC needs a facility to test small components (up to 2") in a flexible, cost-effective mode.
- Testing at the V&CS requires construction of a new test set-up for each test (facility is configured to overhaul valves and perform limited leak and functional testing).
- Testing in the East or West Test Area is costly, time consuming, and not geared to small component testing and rapid test parameter changes.
- Vendors often have trouble testing propulsion system valves at their facilities, as many parameters (such as cryogenic fluids and high pressure flow testing) are outside their normal test capabilities. This facility would be made available to the vendors as needed.
- Provides a capability to independently evaluate vendor component designs.
- Testing of components (such as lines, ducts and instrumentation) would also be performed at this facility.

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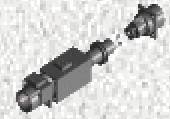

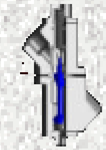



## Can MSFC Afford NOT To Have This Capabilty?

- Risk is unavoidable. Manage risk by understanding the consequence and probability of failure.
- The consequence of a single mission failure due to valve failure would pay for the facility.
- Recent and past engine development programs have shown that the probability of valve failure is higher than acceptable.
- Therefore, risk of valve failure is great unless you can reduce the probability of failure.
- Simple testing of small valves can be more cost effective than analytical modeling.
  - A typical 1" flight valve costs approximately $15,000 (not including ATP and Qualification Testing).
  - This would pay for a thermal and/or stress analyst for only 1 month.
  - If the component is lost during a test, but the loads, thermal properties and/or functional performance of that component are determined; the costs and risks of the program are reduced.
  - Testing is a verification tool.

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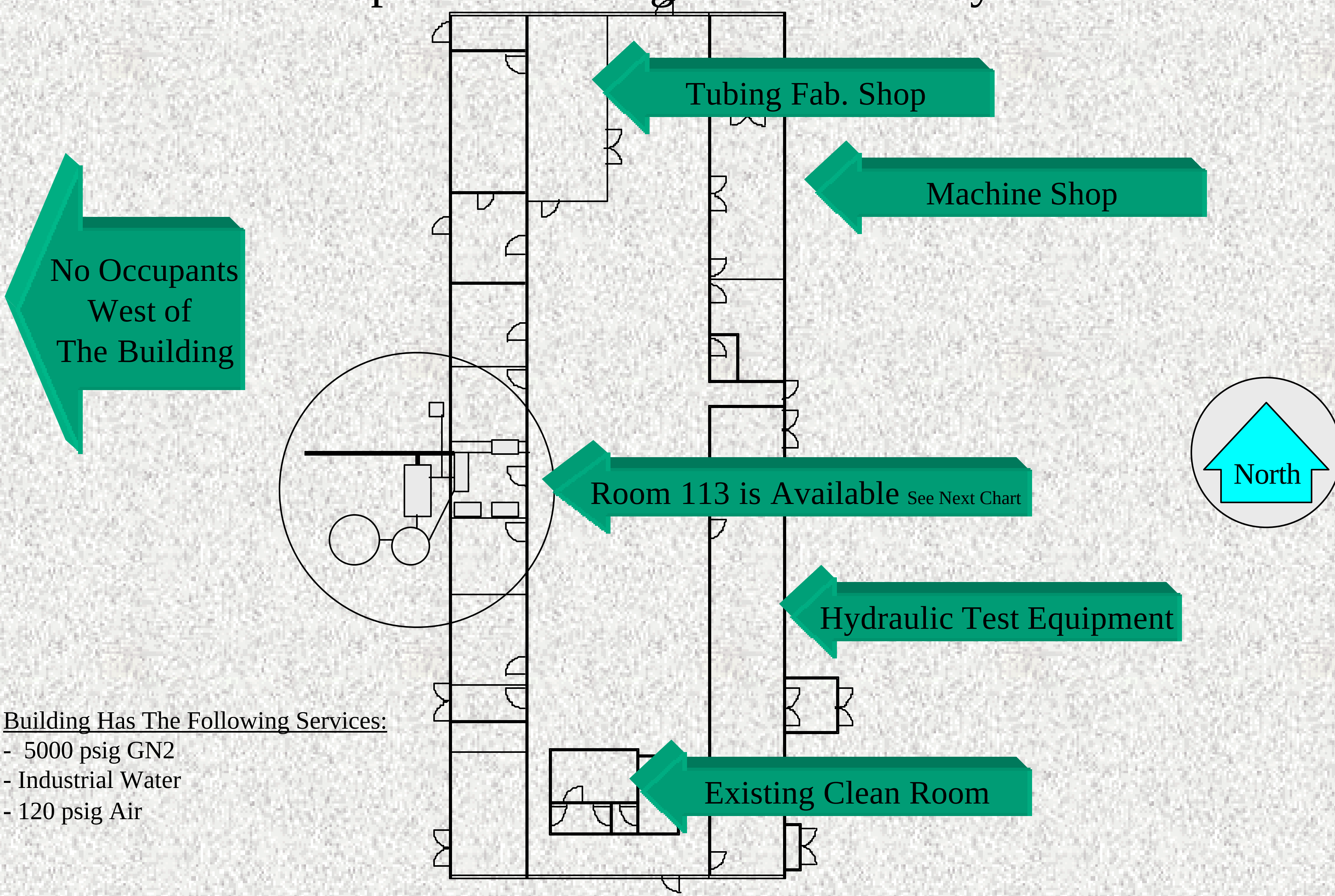
## Ideal CDA Capabilities

- Media:
  - Gases including GN2, GHe & Air.
  - Liquids including Hydraulic, H2O, and LN2.
- Pressures:
  - 5000 psig for gases.
  - 3000 psig Hydraulic fluid.
  - 5000 psig for H20 and LN2.
  - Hydrostatic up-to 10,000 psig.
- Flow testing to 100 GPM (liquid) and 10,000 SCFM (gas) at reduced pressures.
- Environmental chamber from +450 to -150 Deg. F for small components.
- Instrumentation for pressure, flow, position, temperature, leakage, speed, and volume.

# Valve Development/TD62



## Proposed Building 4656 CDA Layout




<u>Building Has The Following Services:</u>

- 5000 psig GN2
- Industrial Water
- 120 psig Air

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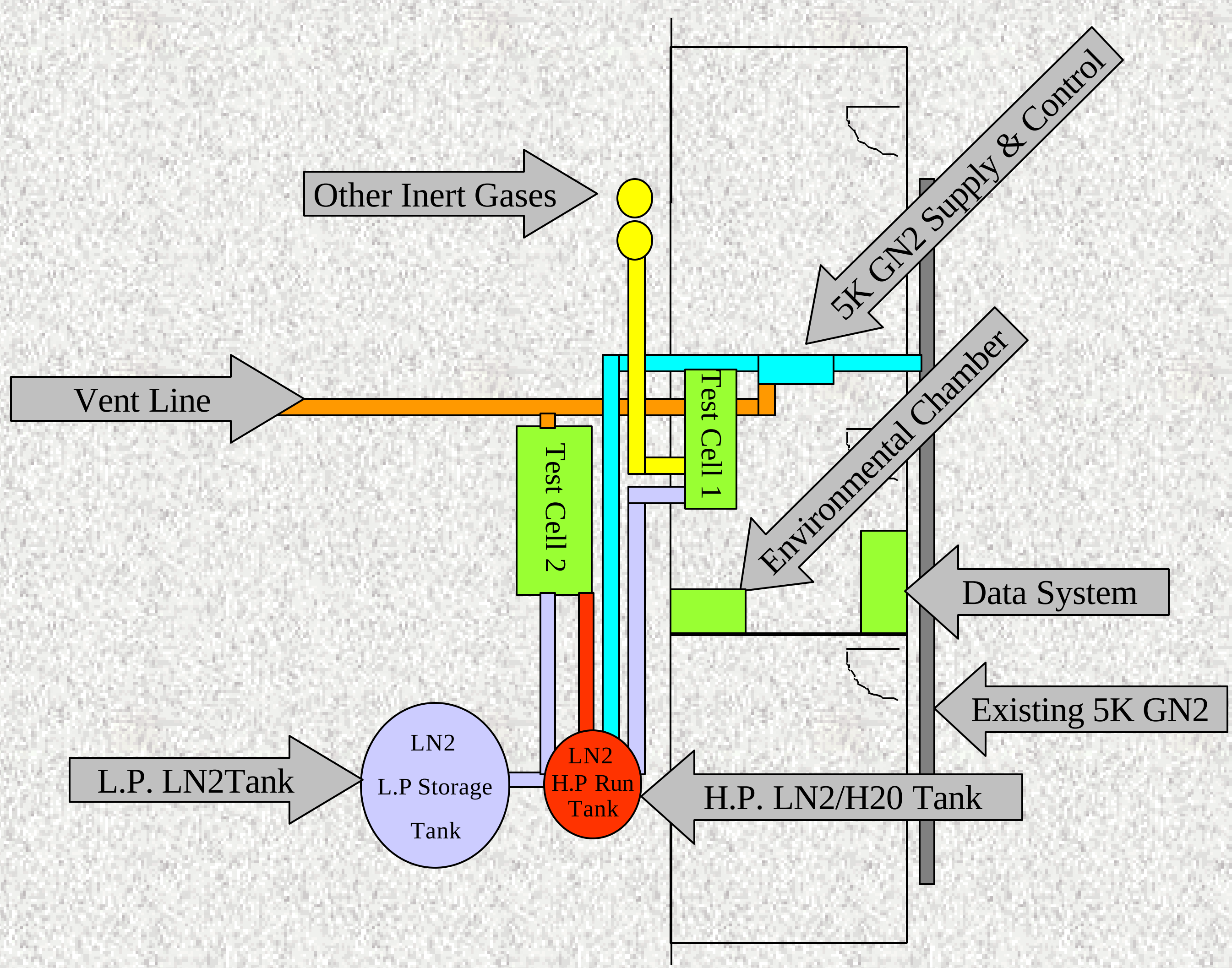
## Generalized Equipment Layout




RM113 Building 4656

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## CDA Fluid System Schematic